



MARKSCHEME

November 2013

CHEMISTRY

Higher Level

Paper 3

*This markscheme is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of the IB Assessment Centre.*

Subject Details: Chemistry HL Paper 3 Markscheme

Mark Allocation

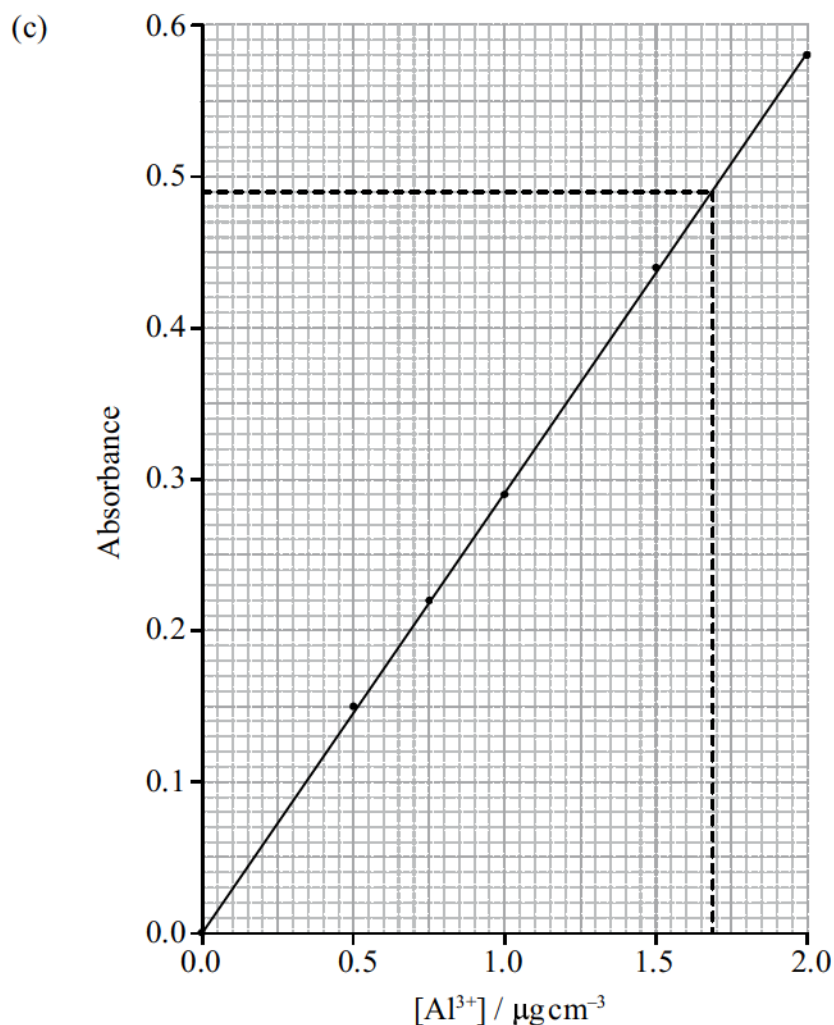
Candidates are required to answer questions from **TWO** of the options [**2 x 25 marks**]. Maximum total = [**50 marks**].

1. A markscheme often has more marking points than the total allows. This is intentional.
2. Each marking point has a separate line and the end is shown by means of a semicolon (;).
3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.
4. Words in brackets () in the markscheme are not necessary to gain the mark.
5. Words that are underlined are essential for the mark.
6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.
7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).
8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.
11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme. Similarly if the formula is specifically asked for, unless directed otherwise in the markscheme, do not award a mark for a correct name.
12. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.
13. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option A — Modern analytical chemistry

1. (a) spin / magnetic moment; [1]
- (b) MRI can detect soft tissues/body organs / different properties of (soft) tissue (and bone);
 Accept “contrast can be a problem in X-ray”. [1]
 Accept three-dimensional image.
2. (a) (i) 90; [2]
 $C_3H_6O_3^+$;
 Penalize missing positive charge of ion only once in (a).
- (ii) $COOH^+$; [1]
 Accept $C_2H_5O^+$.
 Penalize missing positive charge of ion only once in (a).
- (iii) CHO^+ / COH^+ ; [1]
 Accept $C_2H_5^+$ / $CH_3CH_2^+$.
 Penalize missing positive charge of ion only once in (a).
- (b) (i) CH_3 / methyl; [1]
- (ii) $CH_3CH(OH)COOH$; [1]
 Allow full or condensed structural formula.
- (c) quartet means next C has 3 H atoms / is CH_3 ;
 due to the CH group;
 due to relative orientation of spinning nuclei/protons;
 with relative probabilities of 1,3,3,1;
 OH group results in no splitting (due to rapid proton exchange); [3 max]

3. (a) *Similarities [2 max]:*
 1050–1410 cm⁻¹ (due to C–O);
 1700–1750 cm⁻¹ (due to C=O);
 2850–3100 cm⁻¹ (due to C–H);
 3200–3600 cm⁻¹ (due to O–H);
- Differences:*
 1610–1680 cm⁻¹ (due to C=C only in nandrolone); [3]
- (b) can detect very small quantities;
 substance not volatile;
 substance decomposes at high temperature/does not decompose at low temperature; [2 max]
- (c) C=O **and** C=C; [1]
Accept unsaturation or double bonds.
4. (a) light source emits wavelength of light that is absorbed by the element/Al atoms /
 must be an Al lamp/hollow cathode Al lamp; [1]
- (b) *Y:*
 (sample) dehydrated/vaporized/atomized / solvent/water evaporated;
Z:
 absorbs/re-emits radiation / (electromagnetic radiation) excites electrons to higher
 energy levels/states; [2]



line graph based on all six points plotted **and** connected;
Points should be plotted closest to within a half of a small square and extended to the origin.

(concentration =) 1.68 (μg cm⁻³);
 Allow in range 1.65–1.70 (μg cm⁻³).

[2]

5. M as it has more delocalized pi electrons/extensive delocalized pi-bonding system/
 more conjugated;
 M has many (linked) sp² carbon atoms / presence of sp³ hybridized carbon in N limits
 delocalization/conjugation;
 M absorbs light of longer wavelengths/shorter frequencies in the visible region;

[3]

Option B — Human biochemistry

6. (a) alcohol/hydroxyl group **and** alkene; [1]
Accept carbon-carbon double bond.
Do not accept just double bond.
Do not accept hydroxide.
- (b) (i) vitamin C / ascorbic acid; [1]
- (ii) several OH groups / polar molecule; [2]
 able to form hydrogen bonds with water;
- (c) (i) softening/malfunctioning of bones / causes low/deficiency in calcium; [1]
Accept rickets.
- (ii) less time outdoors / skin not exposed due to clothing/sunscreen / *OWTTE*; [1]
Accept answers that show link with outdoors/sunlight.
7. (a)
$$\begin{array}{c} \text{H}_3\text{N}^+ - \text{CH} - \text{COO}^- \\ | \\ \text{CH}_2 - \text{SH} \end{array} ;$$
 [1]
Accept full or condensed structural formulas as long as correct charges on N/NH₃ and O are represented.
Accept NH₃⁺ for H₃N⁺ in the diagram.
- (b) any value or range from 5.1–6.0; [2]
 alanine positive **and** cysteine negative;
Accept biggest charge difference/opposite charges between isoelectric points so move in opposite directions.
Need reference to charges to score M2.
- (c) disulfide bridge; [2]
Accept S–S.
 covalent / strongest bond;

8. (a)
$$\begin{array}{c} \text{C}_{19}\text{H}_{31}\text{CO}—\text{O}—\text{CH}_2 \\ | \\ \text{C}_{13}\text{H}_{27}\text{CO}—\text{O}—\text{CH} \\ | \\ \text{C}_{15}\text{H}_{29}\text{CO}—\text{O}—\text{CH}_2 \end{array} ;$$
 [1]
Accept alternative orders for the hydrocarbon tails.
- (b) water/H₂O **and** enzyme/biological catalyst/lipase; [1]
Accept acidic/alkaline/basic condition instead of water.
Do not award mark for lipase alone without water/ H₂O.
- (c) C₁₉H₃₁COOH; [2]
 they lower level of LDL cholesterol/low-density lipoproteins / reduce (the risk of) heart disease;
Allow comparison with saturated fats with explanation.

9. (a) *Any one for [1 max]:*
 enzymes and inorganic catalysts (provide alternative reaction route with) lower E_a / OWTTE;
 enzymes increase reaction rate by much greater factor than inorganic catalysts / OWTTE;
Do not accept both increase reaction rate.

both have no effect on K /yield of reaction;

Any three for [3 max]:

<i>Enzymes</i>	<i>Inorganic catalysts</i>	
proteins	ions/molecules/varied structure	;
more specific / bind at active site	less specific / no active site / form intermediates / metal catalysts adsorb reactant(s) onto its surface;	;
more sensitive to changes in pH/temperature / work well within a narrow range of conditions	less sensitive to changes in pH/temperature / work well within a wide range of conditions	;
work in aqueous solution/homogeneous phases	can work in other solvents/homogeneous /heterogeneous phases	;
often regulated by inhibitors	usually not regulated by other chemicals / OWTTE	;

[4 max]

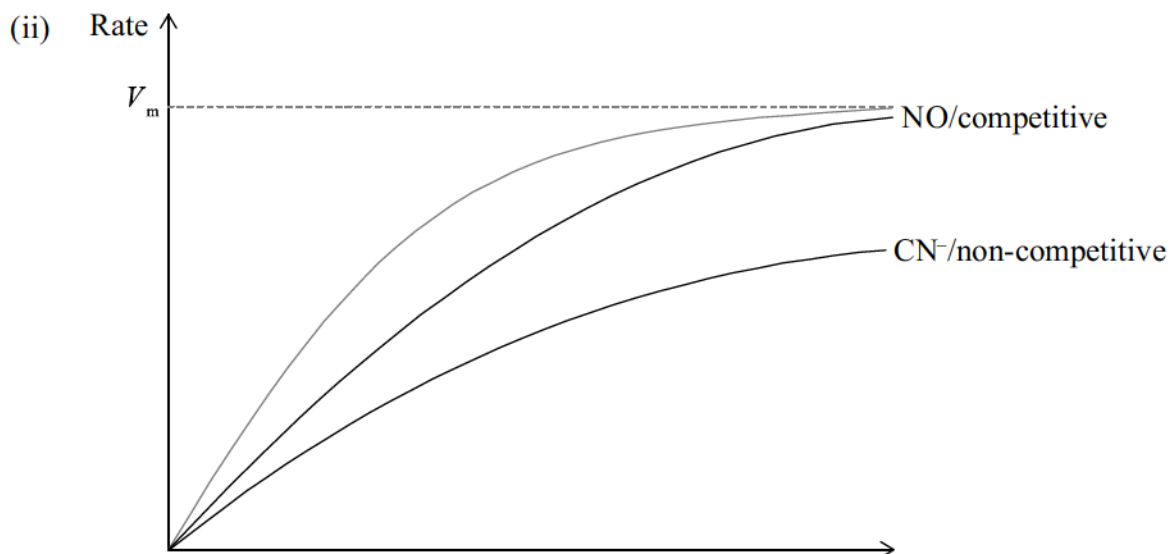
Award [1] for each row, no need for table.

Must make comparative statement for each mark.

Award [1 max] for any three statements with respect to structure and mode without comparison.

- (b) (i) $\text{Cu}^{2+}/\text{Cu}^{+}$ **and** $\text{Fe}^{2+}/\text{Fe}^{3+}$;

[1]



line labelled NO/competitive reaching V_m but with lower gradient;
line labelled CN-/non-competitive not reaching V_m ;

[2]

- (iii) NO more likely to fit into active site / NO (structure) similar to O_2 / CN^-
structure different to O_2 / OWTTE;

[1]

- (iv) $2\text{XH}_2 + \text{O}_2 \rightarrow 2\text{X} + 2\text{H}_2\text{O}$ / $\text{XH}_2 + \text{O}_2 \rightarrow \text{X}(\text{OH})_2$ / $\text{XH}_2 + \text{O}_2 \rightarrow \text{XO} + \text{H}_2\text{O}$;

oxygen changes from 0 to -2 ;

Allow X_2 instead of 2X .

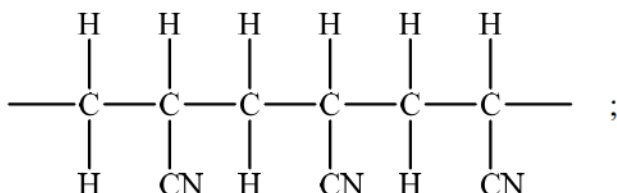
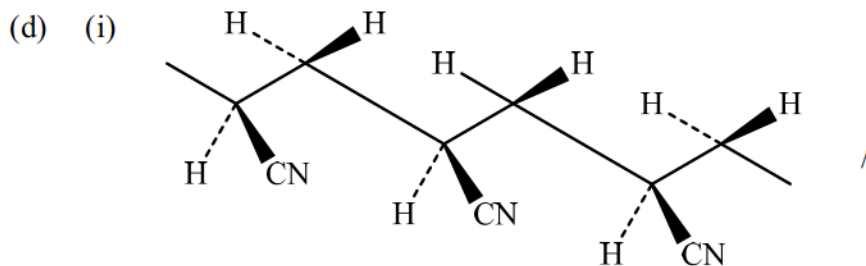
Do not allow 2- notation.

Accept “X changes from -2 to 0 in X or X_2 ” or “X changes from -2 to $+2$ in $\text{X}(\text{OH})_2/\text{XO}$ ”.

[2]

Option C — Chemistry in industry and technology

10. (a) hematite/magnetite/limonite **and** added at P; [1]
Allow P to be indicated on diagram.
- (b) (i) slag / calcium silicate / calcium aluminate; [1]
- (ii) $\text{CaCO}_3(\text{s}) + \text{SiO}_2(\text{s}) \rightarrow \text{CaSiO}_3(\text{s}) + \text{CO}_2(\text{g}) /$
 $\text{CaCO}_3(\text{s}) + \text{Al}_2\text{O}_3(\text{s}) \rightarrow \text{CaAl}_2\text{O}_4(\text{s}) + \text{CO}_2(\text{g});$ [1]
*Accept $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ **and** $\text{CaO}(\text{s}) + \text{SiO}_2(\text{s}) \rightarrow \text{CaSiO}_3(\text{s})$.*
*Accept $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ **and** $\text{CaO}(\text{s}) + \text{Al}_2\text{O}_3(\text{s}) \rightarrow \text{CaAl}_2\text{O}_4(\text{s})$.*
Ignore state symbols.
- (c) (alloying element(s)) atoms/ions have different size;
Allow suitable diagram.
- disrupts regular/repeating (metal) lattice;
- difficult for one layer to slide over another / added atoms/ions smaller than metal
atoms/ions can fit into the (holes of) metal lattice disrupting bonding; [2 max]
If “particles” is penalised in M1, allow “particles” in M3.
- Do not award mark for different or unique properties of alloys.*
11. (a) $\text{RO}\cdot + \text{CH}_2=\text{CH}_2 \rightarrow \text{RO}-\text{CH}_2-\text{CH}_2\cdot;$
 $\text{RO}-\text{CH}_2-\text{CH}_2\cdot + \text{CH}_2=\text{CH}_2 \rightarrow \text{RO}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2\cdot;$ [2]
Accept $\text{R}\cdot$ for $\text{RO}\cdot$.
Penalize missing electron dot only once.
- (b) (free) radical removes a H from within a chain (leaving an unpaired electron which
can then react with other ethene molecules) / $\text{R}\cdot + -\text{CH}_2- \rightarrow \text{RH} + -\text{CH}\cdot-;$ [1]
Accept: (free) radical attacks within the (polymer) chain.
- (c) HDPE uses Ziegler-Natta catalysts/catalyst forms ionic intermediates (LDPE uses
peroxides/catalyst forms free radical intermediates); [1]
Accept heterogeneous (catalyst).



[2]

Continuation bonds at end of structure needed.

Hydrogen atoms must be included.

Award [1] for chain with CN groups on alternate carbons.

Award [2] for correct chain with CN on alternate carbons with same orientation.

- (ii) chains pack together better;
strong intermolecular/attractive forces between chains;
chains do not move past each other easily (so fibre strong/rigid);

[2 max]

12. (a) nothing / whole area black;
Accept no light transmitted.

[1]

- (b) (i) the molecules form a twisted arrangement;
liquid crystal rotates the plane of polarization (so light is now transmitted by the analyser);

[2]

- (ii) (with electric field) the molecules are aligned/not twisted;
so light is not transmitted;

[2]

- (c) rod shape / rigid;
chemically stable (due to hydrocarbon rings and chain);
polar (due to the presence of F) / OWTTE;
can change orientation / rapid switching in electric field/when voltage is applied;

[2 max]

13. (a) $2\text{NiO}(\text{OH})(\text{s}) + \text{Cd}(\text{s}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow 2\text{Ni}(\text{OH})_2(\text{s}) + \text{Cd}(\text{OH})_2(\text{s})$

correct reactants and products with correct coefficients;
correct state symbols corresponding to correct reactants and products in M1;

[2]

- (b) insoluble;
Accept "solids".

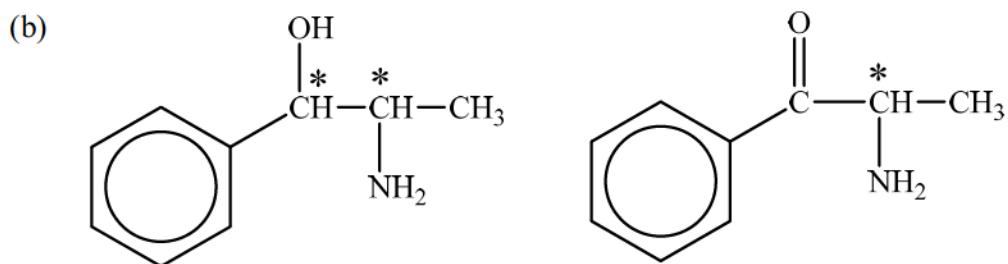
[1]

- (c) arsenic has one more outer electron than silicon / arsenic has five electrons and silicon has four;
spare/extra electron introduced / n-type silicon / extra electrons free to move;

[2]

Option D — Medicines and drugs

14. (a) (i) 2850–3100(cm^{-1}); [1]
- (ii) (OH absorption present) in water/air/water vapour; [1]
- (b) transmittance decreases / absorbance increasing (with increasing concentration); [1]
No mark for: transmittance/absorbance changes.
15. (a) (i) paracetamol/acetaminophen; [1]
- (ii) phenyl **and** (secondary) amide; [1]
Accept benzene ring for phenyl.
Do not allow just benzene or arene instead of phenyl.
- (b) antipyretic/fever reducer / analgesic/pain reducer/killer; [1]
Accept “reduces/inhibits synthesis of (enzyme that produces) prostaglandins”.
Allow ECF from incorrect answer given in (a) (i).
- (c) drugs broken down by acids/enzymes/digestive system before they are absorbed /
 drugs reach target more slowly / *OWTTE*; [1]
- (d) starting materials (covalently) bonded to resin beads/solid phase;
 reagents mixed together then split into portions;
 mixed and split again to react with new reactants;
 process repeated until (combinatorial) library is produced; [3 max]
Allow suitably labelled diagram.
16. (a) phenyl **and** amine (on side-chain); [1]
Accept benzene ring in place of phenyl.
Accept (both) derived from phenylethylamine.



All three chiral centres need to be identified for the mark.

[1]

- (c) (i) chiral auxiliary/optically active species is used;
that can be connected to a molecule / to make it optically active;
auxiliary creates stereochemical condition necessary to follow a certain
pathway / forms (only) one enantiomer / *OWTTE*;
chiral auxiliary removed to obtain (desired) product; [3 max]

- (ii) other methods produce racemic mixture;
enantiomers difficult to separate because they have same physical properties
(except rotation of the plane of plane polarised light);
optical isomers might have different physiological activities/(usually)
only one is useful/half product is not used; [2 max]

- (iii) add acid/H⁺(aq) (to form ionic compound) / converted to its salt; [1]

- (d) *For [1 max]:*
specific effect on certain diseases e.g. relieves nausea in cancer patients to gain
mass/weight / relieves glaucoma/Parkinson's disease/multiple sclerosis / increases
appetite in AIDS patients;

personal freedom argument / frees police to deal with other/more serious crimes /
more taxes / *OWTTE*;

*No mark for comment such as "cannabis is no more harmful than other legal
drugs so why should cannabis be different".*

Against [1 max]:
increased risk of lung cancer / respiratory ailments / may suppress body's immune
system;

may lead to use of harder drugs/heroin/cocaine; [2 max]
Do not allow "cost/negative impact on society" without specifying its impact.

17. (a) Cl⁻ leave Pt/Pt²⁺ **and** (dative covalent/coordinate) bond forms between Pt/Pt²⁺ and
DNA/guanine; [1]

- (b) *trans* formation/geometry/Cl groups on opposite side does not allow the molecule
to attach to two bases/places in the same DNA chain; [1]
Mark requires more than just stating trans geometry.

18. viruses mutate quickly so adapt to drugs/evade immune system response / *OWTTE*;

bacteria are more complex and thus can be targeted in more ways / viruses lack
sub-units/functions targeted by antibacterials / *OWTTE*;

different types of bacteria employ similar metabolic processes and thus can be targeted
by common antibacterials / each kind of virus usually requires special drugs/approaches
/ *OWTTE*;

bacteria can be killed by interfering with cell wall production without attacking host cell /
difficult to attack the virus without attacking host cell; [3 max]

Option E — Environmental chemistry

19. (a) amount of oxygen needed to decompose/oxidize organic/biological matter/waste;
in specified time/5 days / at specified temperature/ 20 °C ; [2]
Award [1] for “measure of the organic matter in water” / OWTTE
- (b) (i) O₂ used in aerobic respiration / by aerobic bacteria / breakdown of X
uses O₂; [1]
- (ii) O₂ dissolving from air;
oxygen consumption for decomposition/oxidation of X is decreased/completed; [2]
- (iii) days 9/10 – 12/13; [1]
- (c) line/curve with negative gradient; [1]
20. (a) *Physical [1 max]:*
improves structural stability;
influences water retention properties;
increases cation exchange capacity (due to presence of humus);
thermal properties / absorbs heat;
- Biological [1 max]:*
source of nutrients (for stronger plant growth);
chelates to nutrient ions (preventing these from precipitating out);
behaves as a buffer/controls pH;
reduces/limits absorption of pesticides/heavy metal ions (through its chelating ability);
provides source of heat; [2 max]
- (b) (i) $K_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2$;
 $1.80 \times 10^{-11} = (x)(2x)^2 = 4x^3$ / $x = 1.65 \times 10^{-4}$;
 $[\text{Mg}^{2+}] = 1.65 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ **and** $[\text{OH}^-] = 3.30 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$;
 $(\text{pOH} = -\log 3.30 \times 10^{-4} = 3.48 \text{ so } \text{pH} = (14 - 3.48) = 10.5$; [4]
Accept values from 10 to 11.
Do not penalize incorrect significant figures throughout.
Allow [2 max] for final correct pH if no working shown.
- (ii) pH lower because lower concentration of OH[−] ions / lower solubility/K_{sp}; [1]
Must give reason to score mark.
Award mark for valid calculation.
- (iii) at higher pH (pH > 5 / 6) Al³⁺/aluminum ion precipitates out (as Al(OH)₃)
/ as [OH[−]] increases, Al(OH)₃ ⇌ Al³⁺ + 3OH[−] shifts to left;
available Al³⁺/Al³⁺ (aq) concentration lower at higher pH; [2]

21. (a) $\text{O}_3(\text{g}) \rightarrow \text{O}_2(\text{g}) + \text{O}\cdot(\text{g})$ **and** $\lambda > 330 \text{ nm}$ / long wavelength UV;
Accept UV alone.



Ignore state symbols.
Allow O for radical.

- (b) Chlorofluorocarbons/CFCs **and** oxides of nitrogen/ NO_x . [1]

- (c) (i) $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g});$
 $\text{NO}_2(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{O}\cdot(\text{g})$ / photochemical reaction / photo-dissociation /
 sunshine / UV (light);
 $\text{O}\cdot(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{O}_3(\text{g});$ [3]
 Ignore state symbols.
 Allow O for radical.

- (ii) Any two for [1]:
 primary pollutants/reactants trapped/concentrated;
 inversion/cooler denser air trapped at ground level;
 windlessness;
 bowl-shaped location;
 bright sunshine; [1 max]

22. Source:
 protective clothing/gloves / plastic bags / paper towels;

Storage/disposal method:
 storage in cooled water/ponds / buried underground/in dedicated landfills/
 shallow-lined trenches/steel/metal containers; [2]

Option F — Food chemistry

23. (a) (i) alcohol/hydroxyl **and** phenyl; [1]
Accept benzene ring in place of phenyl.
Do not allow hydroxide or just benzene or arene.
- (ii) tertiary carbon (atom)/butyl group / C bonded directly to 3 methyl groups/
 3 carbon (atoms); [1]
- (iii) $C_{15}H_{24}O$; [1]
- (b) *Natural antioxidants:*
 act as reducing agents / electron donors;
 remove or reduce concentration of oxygen/react with oxygen;
 preferentially oxidized (instead of fat and oil); [2 max]
- Synthetic antioxidants:*
 act as free radical quenchers / form more stable/less reactive radicals (due to
 tertiary butyl group);
 may inhibit formation of radicals/radical initiation step;
 may interrupt propagation step;
 may absorb radicals in termination step;
- Award [1 max] for the following in either type of antioxidant:*
 chelating agents remove metal ions from solution / prevent metal catalysis; [2 max]
- (c) SO_2 more like carotenoid as it is a reducing agent / SO_2 more like BHA/BHT
 because it can react with free radicals; [1]
- (d) (i) *Any two for [1]:*
 carrot, squash, broccoli, sweet potato, tomato, kale, peach, apricot,
 cantaloupe, mango, papaya, yam; [1 max]
Do not allow just melon.
- (ii) *Any two for [1]:*
 vitamin C/ascorbic acid, vitamin E, selenium; [1 max]

24. (a) stearic acid;
saturated molecule / more closely packed / greater surface area (of contact) / not “kinked”;
more/stronger van der Waals’ forces; [3]
Accept intermolecular/London/dispersion forces instead of van der Waals’ forces.

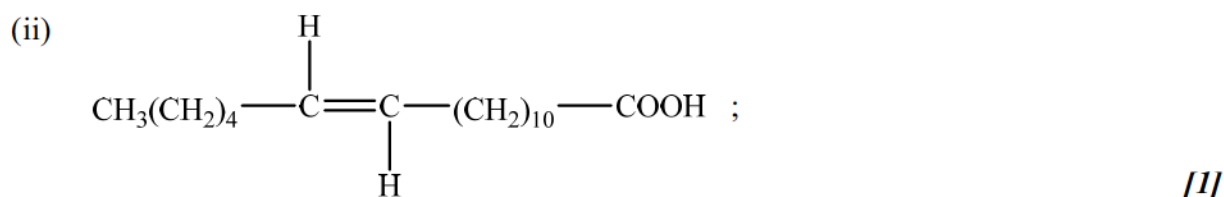
- (b) $\text{C}_{17}\text{H}_{29}\text{COOH(l)} + 3\text{H}_2\text{(g)} \rightarrow \text{C}_{17}\text{H}_{35}\text{COOH(l)}$;
Ignore state symbols.
Accept either condensed structural formulas or molecular formulas.

Any two correct conditions for second mark:
high temperature/heat;
Accept any temperature value/range greater than 100 °C .

(high) pressure;
(finely divided catalyst) Zn / Cu / Ni / Pt / Pd; [2 max]
Accept room temperature only if Pt or Pd is given as catalyst.

Note to examiners: it is very easy in Scoris to give one mark before two conditions are given.

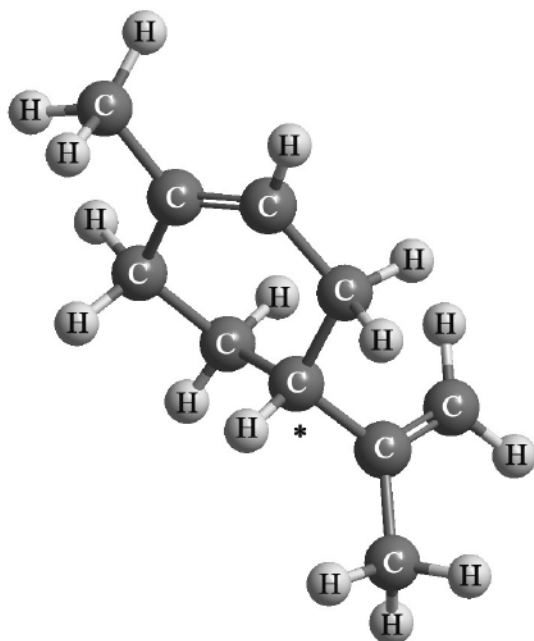
- (c) (i) *trans* fats have functional/bulky groups/hydrogen atoms on opposite sides of the carbon-carbon double bond; [1]



Award mark for structures showing one or two double bonds with trans arrangement correctly shown.
Accept R as long as the trans arrangement is clear.
Ignore errors in hydrocarbon chain/position of double bonds so long as trans arrangement is clear.

25. (a) kinetically stable mixture of one phase in another largely immiscible phase; [1]
- (b) *Emulsion*: unwhipped cream / butter **and** *Foam*: whipped cream; [1]
Accept beer as example of foam.
- (c) polar/hydrophilic/dissolves in water **and** non-polar/hydrophobic/dissolves in oil/fat; [1]

26. (a)



;

[1]

- (b) differ in taste **and** odours/smell;
Accept toxicity for either taste or smell.

[1]

- (c) *Experiment A:* from natural source optically active **and** *Experiment B:* from chemical synthesis not optically active;

Experiment A:

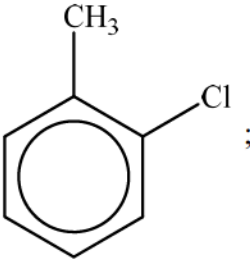
natural source limonene is single/pure enantiomer (which gives single enantiomer/optically active product);

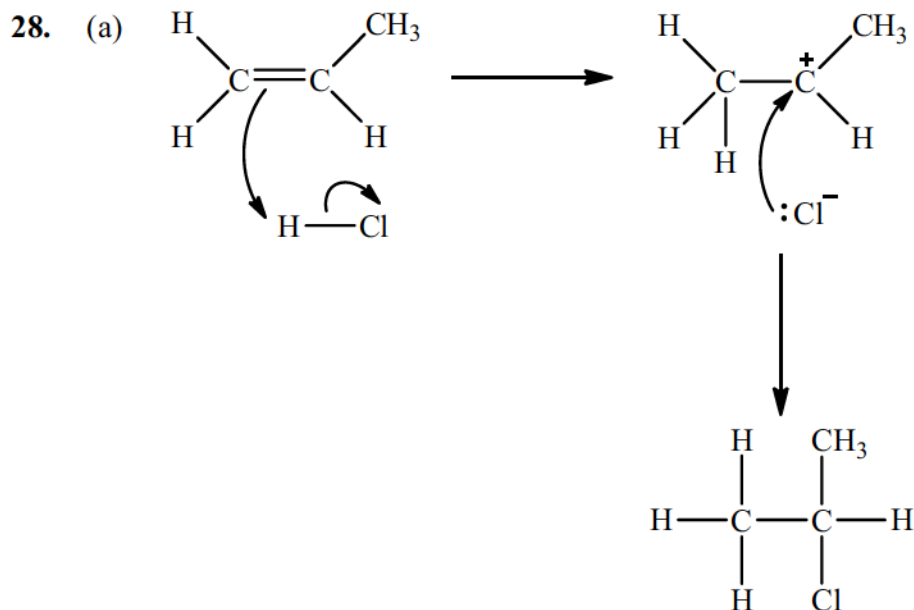
Experiment B:

synthetic source limonene is mixture of enantiomers / racemic mixture (which gives racemic mixture/not optically active product);

[3]

Option G — Further organic chemistry

27. (a) (i) (circle represents six) delocalized electrons (over 6 C–C bonds); [1]
 Allow “delocalized pi-bonds”.
 Accept “resonance”.
- (ii) C–C/bond length/order is intermediate between double and single/1.5; [1]
- (b) (i) conjugate base/ion more stable as negative charge spread out/delocalized on the ring;
 lone/non-bonding pair on oxygen can interact with delocalized electrons of benzene/aromatic ring / orbital overlap between non-bonding pair and aromatic system; [2]
- (ii) NO₂ group is electron withdrawing/negative inductive effect / more delocalization (over more atoms);
 Do not just accept “NO₂ deactivating”.
 negative charge delocalized on the ring **and** NO₂ group / negative charge on oxygen/conjugate base decreases more (because of the presence of the NO₂ group, thus easier for H⁺ to leave); [2]
- (iii) NO₂⁺; [1]
- (c) *Product F:*
 Cl₂ and UV/hν/sunlight;
- Product G:*
 Cl₂ and AlCl₃/Fe/FeCl₃; [2]
- (d)  [1]
- (e) methyl group directs groups to 2 and 4 position due to positive inductive effect/ as it is electron releasing/donating;
 stable / increased charge density (in these positions); [2]

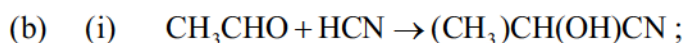


curly arrow going from C=C to H of HCl **and** curly arrow showing Cl leaving;
representation of carbocation;

curly arrow going from lone pair/negative charge on Cl to C⁺;

formation of CH₃CHClCH₃;

[4]

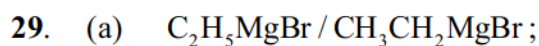


Allow product formula without brackets provided it is clear.

[1]

(ii) nucleophilic addition;

[1]



[1]

(b) (i) carbon dioxide/ CO_2 **and** water/ H_2O ;

Accept dilute HCl(aq) instead of water/H₂O.

[1]

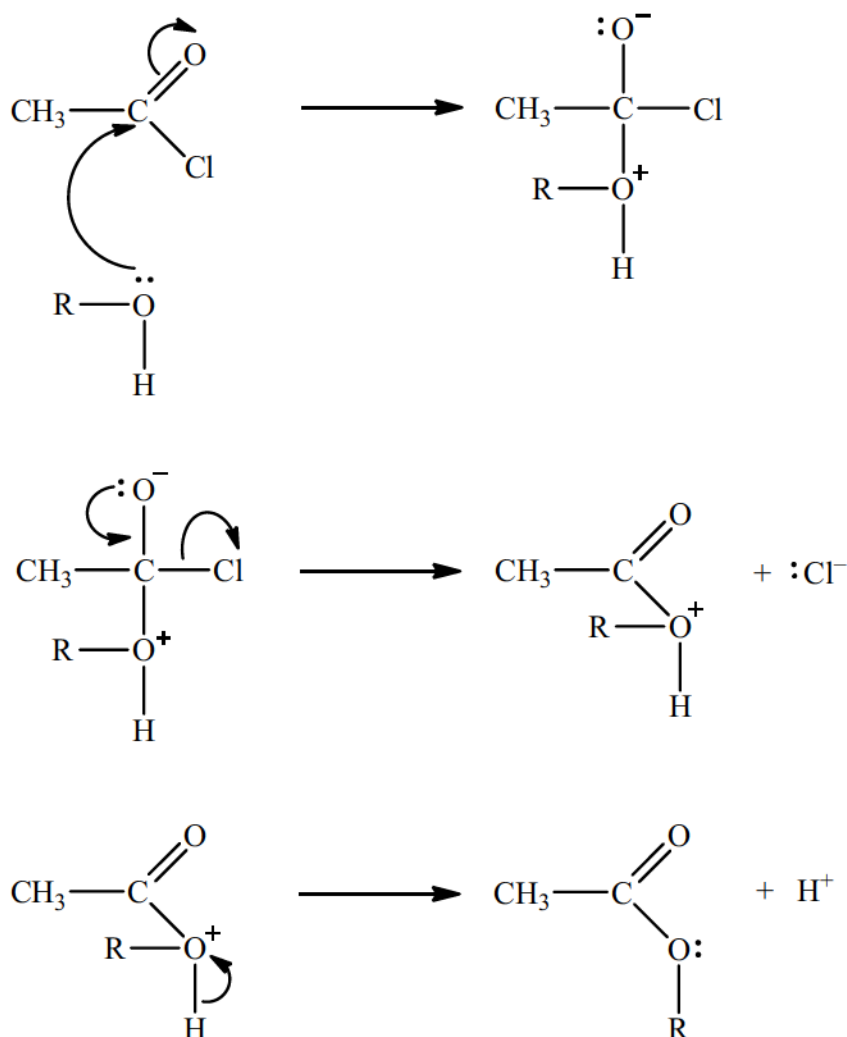
(ii) propanone/acetone/ $(\text{CH}_3)_2\text{CO}$ **and** water/ H_2O ;

Accept dilute HCl(aq) instead of water/H₂O.

[1]

Only penalize missing H₂O once in (b).

30.



curly arrow going from lone pair on O to carbonyl C **and** curly arrow going from C=O bond to O;

Partial charges not required.

representation of intermediate showing negative charge on O **and** positive charge on O;
Lone pair on O not required on representation of intermediate.

curly arrow going from lone pair/negative charge on O to C–O to form C=O **and** curly arrow showing Cl leaving;

curly arrow going from OH bond to O⁺ **and** formation of CH₃COOR **and** H⁺ **and** Cl[–] (somewhere in mechanism);

[4]